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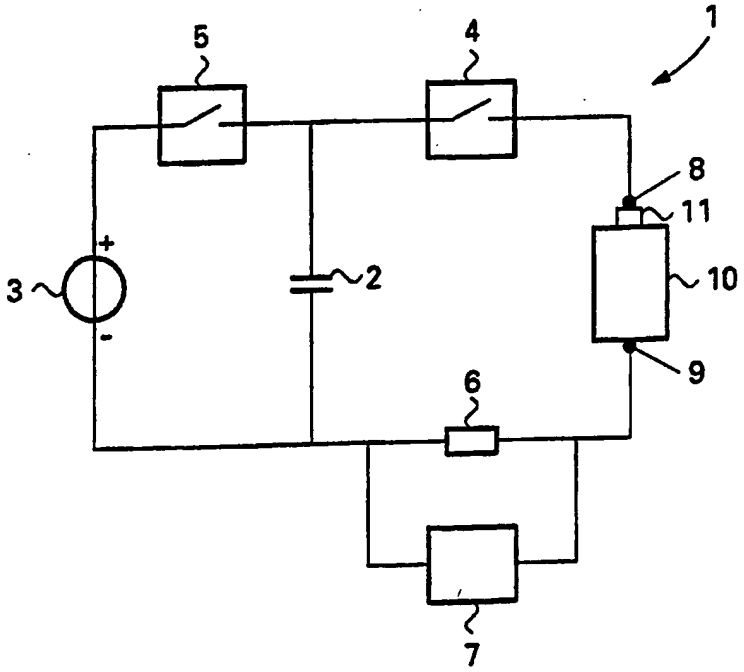
(54) Title: A METHOD AND DEVICE FOR SORTING BATTERIES

(57) Abstract

The invention relates to a method for sorting batteries (10), with batteries being separated on the basis of a measured electrical property which is characteristic of their composition. The electric property of the battery is according to the invention determined by applying to the battery (10) a varying electrical voltage and measuring the resulting current through the battery. The varying electrical voltage advantageously consists of a first pulse and a second pulse which have opposite polarities, and which may both be generated by the discharge of a capacitor (2). In addition, a second property may be determined, e.g., the shape or colour of the battery. With such method, a very effective separation between, e.g., nickel-cadmium, alkaline, lithium, and other batteries may be obtained. The invention further relates to a device (1) for determining electrical properties of batteries.



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A method and device for sorting batteries.

BACKGROUND OF THE INVENTION

The invention relates to a method for sorting batteries based on their composition, comprising the determination of at least one property characteristic of the composition of a battery, and the subsequent separation of batteries on the basis of the at least one property. The invention further relates to a device for implementing the method. Such method, as well as devices for the implementation thereof, are generally known.

Used batteries constitute an ever increasing threat to the environment. The substances present in the batteries are often harmful and cannot simply be dumped. Recycling or removing such substances is often basically possible but in practice runs up against great problems, since different battery types contain a great diversity of substances. Recovering certain substances is feasible only if such substances are well capable of being separated. For this purpose, it is required to effectively sort batteries prior to the recovering process.

Known methods for sorting batteries are usually based on mechanical sorting by size. Thus, DE 4,310,862 [Reference 1] discloses a method for mechanically sorting used batteries, use being made of sieves having holes with varying diameters.

Although in some cases such known method may be useful, a clear separation between the various battery types is not always well possible, since the measured properties of some battery types lie very close together. Thus, many rechargeable batteries have the same shape and size as non-rechargeable ones, while their chemical composition is fundamentally different. An effective sorting process, in which batteries having a fundamentally different

composition are separated with a very small error percentage, is therefore not possible with this known method.

WO 92/17791 [Reference 2] discloses a method and device for sorting used batteries, with the batteries first being mechanically sorted on the basis of shape and size, and subsequently being sorted on the basis of their chemical composition. In WO 92/17791, it is proposed to determine the chemical composition by conducting the battery through a coil and using the resulting distribution of the ferromagnetic mass as a separation criterion.

This prior art method is based on the assumption that batteries with a different chemical composition also have a different metal housing. Since currently most battery housings are made of steel, this known method is not very useful. In addition, the distribution of the ferromagnetic mass, as described in said international patent application, does not always provide a clear separation between the battery types, even if they have different housings.

GB 2 130 735 [Reference 3] discloses an apparatus in which a capacitor is discharged through a battery in order to determine its internal resistance. However, this prior art apparatus is designed to test batteries in use, i.e. batteries in operating conditions, not discarded used batteries.

SUMMARY OF THE INVENTION

The object of the invention is to eliminate the above and other drawbacks of the prior art, and to provide a method which makes it possible to separate various battery types in an effective manner, i.e., with a very small error probability, and thus to sort them. A specific object of the invention is to provide a method which makes it possible to effectively separate rechargeable and non-rechargeable batteries, particularly nickel-cadmium batteries and

other batteries.

For this purpose, a method of the type referred to in the preamble is characterised, according to the invention, in that said at least one property comprises the internal electrical resistance, measured by applying to the battery at least a first and a second pulse and measuring the resulting current through the battery, said first and second pulse having opposite polarities.

It has turned out that on the basis of one or more electrical properties a very effective and reliable separation of batteries, and therewith a very useful sorting process, may be obtained.

An electrical property may be determined by applying to the battery a varying voltage and measuring the resulting current through the battery. As a result, a very useful property is obtained, namely, the (dynamic) internal resistance of the battery. Such a varying voltage may be an AC voltage, but preferably the varying voltage is formed by one or several pulses. Thereby it is avoided that, by applying a large series of pulses (as in the event of an AC voltage), the battery is heated, as a result of which the electric properties of the battery might be affected.

Advantageously, use is made of a first pulse and a second pulse, which pulses have an opposite polarity. By applying two pulses with an opposite polarity, a very effective determination of the battery type may be obtained, since the (dynamic) internal resistance of some battery types turns out to depend on the direction of the current.

A pulse is advantageously generated by discharging a capacitor. In this manner, a pulse may be generated with a relatively high current intensity during a brief period of time. The high current intensity provides a reliable determination of the (dynamic) internal resistance, while the short duration prevents overload of the battery.

It should be noted that GB 2 130 735 [Reference 3] teaches away from the present invention in that said reference discloses a polarity detector capable of de-activating the means for discharging the capacitor in response to reverse connection of the battery to be tested in the apparatus. That is, according to the above-mentioned reference a battery to be tested should not be supplied a pulse in reverse direction. The present invention, however, is based on the insight that two (or more) pulses having different polarities, i.e. different directions, yield highly useful test results.

In addition to the determination of electric properties, other properties may be determined and applied to the sorting process, such as the colour and shape of the batteries.

The invention further provides a device for implementing the inventive method.

EXEMPLARY EMBODIMENTS

The invention will be further explained below with reference to the Figures.

Fig. 1 schematically shows a circuit for implementing the method according to the invention.

Fig. 2 schematically shows measurement results obtained with the help of the circuit of Fig. 1.

Fig. 3 schematically shows a device for determining supplementary properties of batteries.

The circuit 1 for executing the method according to the invention shown by way of example in Fig. 1 comprises a capacitor 2, a voltage source 3, a first switch 4, a second switch 5, a resistor 6, a measuring instrument 7, and contacts 8 and 9. Between the contacts 8 and 9, there is mounted a

battery 10 with a battery contact (positive terminal) 11.

In the rest position, both switches 4 and 5 are opened. When the second switch 5 is closed, the capacitor 2 is charged from the voltage source 3. When the capacitor 2 has been charged, the switch 5 is opened and the circuit is operational.

When the switch 4 is closed, the capacitor 2 discharges by way of the switch 4, the first contact 8, the battery 10, the second contact 9, and the resistor 6, and in this circuit there will start to run a current which depends on electric properties of the battery 10. In the resistor 6, said current (discharge current) generates a voltage which is measured by the measuring instrument 7 connected in parallel to the resistor 6. The measuring instrument 7 may, e.g., be a voltmeter or an oscilloscope, but also a digital signal-processing device. The voltage gradient measured by the measuring instrument 7 is therefore indicative of electric properties of the battery 10. The gradient of said so-called discharge voltage is shown in Fig. 2. In practice, the exact duration and amplitude of the discharge voltages will depend on the value of the capacitor 2 and the resistor 6, and on the (dynamic) internal resistance of the battery 10. Suitable values of the capacitor 2 and of the resistor 6 are 1000 μF and 0.1 Ω, respectively, but other values are also possible, of course. The voltage of the voltage source 3 may, e.g., be 15 V.

It has turned out that different battery types react very differently to a discharge of the capacitor (generally: a pulse), particularly as a function of the way in which the batteries are connected (i.e., the polarity of the pulse). In Fig. 2A, the voltage gradient is shown for a nickel-cadmium battery. At the point in time t1, the switch 4 is closed and the battery 10 is connected in the manner shown in Fig. 1, i.e., with the positive terminal (11 in Fig. 1) to the

first (positive) contact 8.

At the point in time t2, the first switch 4 is closed once again, after the polarity of the battery 10 has first been reversed and after the capacitor 2, by means of (temporarily) closing the second switch 5, has been charged once again. Reversing the polarity of the battery may take place in the diagram of Fig. 1 by removing the battery 10 and remounting it between the contacts 8 and 9, but this time with the positive terminal 11 against the contact 9.

By closing the first switch 4, the capacitor 2 is discharged once again and the discharge current runs through the battery 10 in the opposite direction. The principle of the invention now lies in the fact that different battery types, particularly after reversing their polarity, show different discharge currents and therefore show a different (dynamic) internal resistance. As shown in Fig. 2A for nickel-cadmium batteries, the discharge current, and therefore the discharge voltage measured in the measuring instrument 7, from the point in time t2 onwards runs in the opposite direction (case II), substantially the same as after the point in time t1 in the original direction (case I). In both cases, the discharge voltages measured amount to (approximately) V_1. In Fig. 2B however, in which the results for lithium batteries are shown, the discharge voltage in case II is considerably lower than in case I, and may even be substantially equal to zero. The lithium battery turns out to operate as a diode, at any rate for pulses. In Fig. 2C, in which the results are shown for several other battery types, such as carbon-zinc and alkaline batteries, the discharge voltage in case II (V_2), although lower than in Fig. 2A, is considerably higher than in case 2B. In case II of Fig. 2C, the voltage generated by the discharge current in the resistor 6 may amount to approximately half the voltage in case I ($V_2 \approx 0.5 \times V_1$). In the manner described above, the various battery types can therefore be well distinguished.

It is possible, of course, to use other pulse shapes than the discharge pulse of a capacitor described above, such as sawtooth pulses, spikes and the like. Applying an AC voltage (whether sinusoidal or not) is also basically possible, as well as applying a DC voltage, possibly in combination with a pulse-shaped voltage. It will further be understood that the circuit 1 of Fig. 1 is primarily intended to clarify the principle of the invention and that many other circuits are possible, e.g., circuits in which said reversal of polarity takes place electromechanically or electronically and the battery need therefore not be removed. Furthermore, the switches 4 and 5 may be combined in one selector switch connecting either the voltage source 3 or the battery 10 to the capacitor 2. In series with the voltage source 3, a resistor may be included to limit the charge current of the capacitor. In practice, the contacts 8 and 9 are preferably constructed in pointed shape in order to obtain a low contact resistance.

In the first discharge current (case I in the Figures 2A, 2B and 2C), differences may occur in amplitude, i.e., the values V_1 (which are indicative of the internal resistance of the batteries) may differ between the battery types. Such differences may also be applied as a property, preferably in combination with the differences in the internal resistance described above, which depend on the direction of the current. Furthermore, the residual voltage of the battery may also be applied as a supplementary electric property, i.e., the terminal voltage of the battery which may be measured by connecting the terminals of the battery to a measuring instrument. This residual voltage is preferably measured before the internal resistance is determined, in order to prevent mutual influencing.

A combination of electric properties may therefore be advantageously used to sort batteries on the basis of their composition.

The means shown in Fig. 3, by way of example, for carrying out a supplementary sorting step (prior or post-selection) on the basis of visual properties comprise an inclined plane 12, a first conveyor belt 13, a second conveyor belt 14, a light source 15 and an optical sensor 16, which is connected to a processing device (computer) 17. A battery 10 rolls down along the inclined plane 12, while a next battery 10' is supplied by the first conveyor belt 13. The arrows indicate the direction of movement of the batteries. The centre lines of the light source 15 and the sensor 16 are indicated by dotted lines.

The optical sensor 16 may comprise one or more optical detectors (e.g., light-sensitive cells) provided with a colour filter for selectively observing colours of the battery. The light source 15 and the sensor 16 are positioned in such a manner that light originating from the light source may reach the sensor 16 by way of the battery 10 (as indicated by the dotted lines in Fig. 3). In the event that sufficient ambient light is available and no specific requirements are imposed on the colour of the light, the light source 15 may be omitted. The sensor 16 is preferably constructed and mounted with respect to the rolling batteries in such a manner that at least once the entire circumference of a battery may be observed by the sensor 16.

Instead of one or more light-sensitive cells, the optical sensor 16 may comprise a CCD, so that in processing device 17 an analysis on shape and/or colour may be carried out (image recognition). In this case, a data file with colour and/or shape properties of batteries may advantageously be composed, preferably in a self-learning system.

If necessary, an image analysis may also be carried out completely independently from the determination of electric properties, so that batteries are sorted exclusively on the basis of their shape, if necessary supplemented

by their colour.

A device for implementing the method according to the invention comprises means for contacting batteries, means for applying test pulses, means for processing responses, as well as mechanical means for separating batteries. Preferably, such device also comprises means (known per se) for carrying out a mechanical preselection, such as a sieve having openings with various diameters.

A device according to the invention may carry out, e.g., the following process steps:

1. determining a supplementary property, such as the size of the battery, with the help of, e.g., grids (known per se) having openings with various diameters, or the colour of the battery with the help of a light source and an optical sensor;
2. preselecting on the basis of the results of determining the supplementary property;
3. determining the electric property, preferably determining the dynamic internal resistance of the battery, if necessary in combination with other electric properties;
4. actually sorting on the basis of the electric property;
5. (possibly) post-sorting on the basis of a supplementary property (whether used in the above or not).

Physically separating the batteries on the basis of the properties found may be effected with sorting devices known per se. The prior and post-sorting may be carried out according to need.

It will be understood by those skilled in the art that the invention is not limited to the embodiments shown, and that many modifications and additions are possible without departing from the scope of the invention.

REFERENCES

[1] DE 4 310 862

[2] WO 92/17791

[3] GB 2 130 735

[4] EP 0 611 106

[5] EP 0 580 241

CLAIMS

1. Method for sorting batteries based on their composition, comprising the determination of at least one property characteristic of the composition of a battery (10), and the subsequent separation of batteries on the basis of the at least one property, characterised in that said at least one property comprises the internal electrical resistance, measured by applying to the battery at least a first and a second pulse and measuring the resulting current through the battery (10), said first and second pulse having opposite polarities.

2. Method according to claim 1, wherein said pulses are comprised in an AC voltage.

3. Method according to claim 1 or 2, wherein a pulse is generated by the discharge of a capacitor (2).

4. Method according to any of the preceding claims, wherein the magnitude of the current through a battery is used to separate batteries into at least three groups.

5. Method according to any of the preceding claims, wherein there is also determined a second property of a battery.

6. Method according to claim 5, wherein the second property is used for making a sorting step prior to, or after, determining the electrical resistance.

7. Method according to claim 5 or 6, wherein the second property comprises colours of the batteries.

8. Method according to claim 5, 6 or 7, wherein the second property comprises the shape of the batteries.

9. Method according to claim 7 or 8, wherein the second property is determined with the help of image-processing techniques.

10. Device for implementing the method according to any of the preceding claims, the device comprising means (8, 9) for contacting batteries (10),

means (2-5) for applying test pulses, and means (7) for processing responses, characterised in that said means (2-5) for applying test pulses are arranged for applying test pulses having alternating polarities.

11. Device according to claim 10, further comprising mechanical means for separating batteries (10) on the basis of information provided with the means (7) for processing responses.

12. Device according to claim 11 or 12, further comprising means for carrying out a mechanical preselection of the batteries (10).

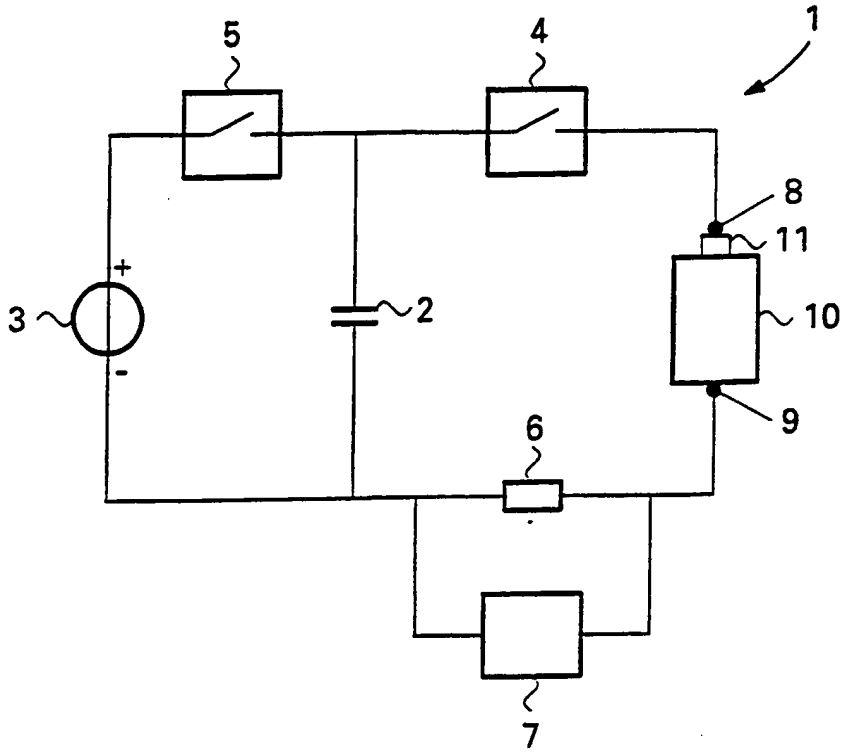

Fig. 1

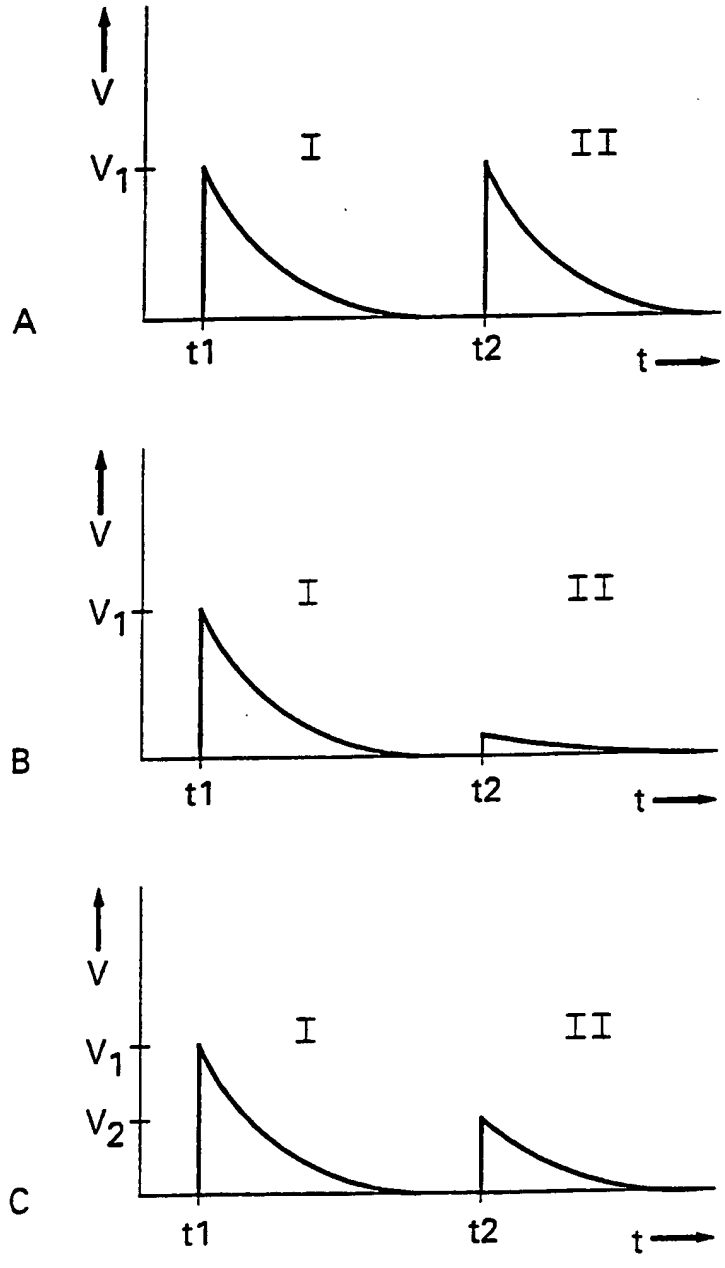

Fig. 2

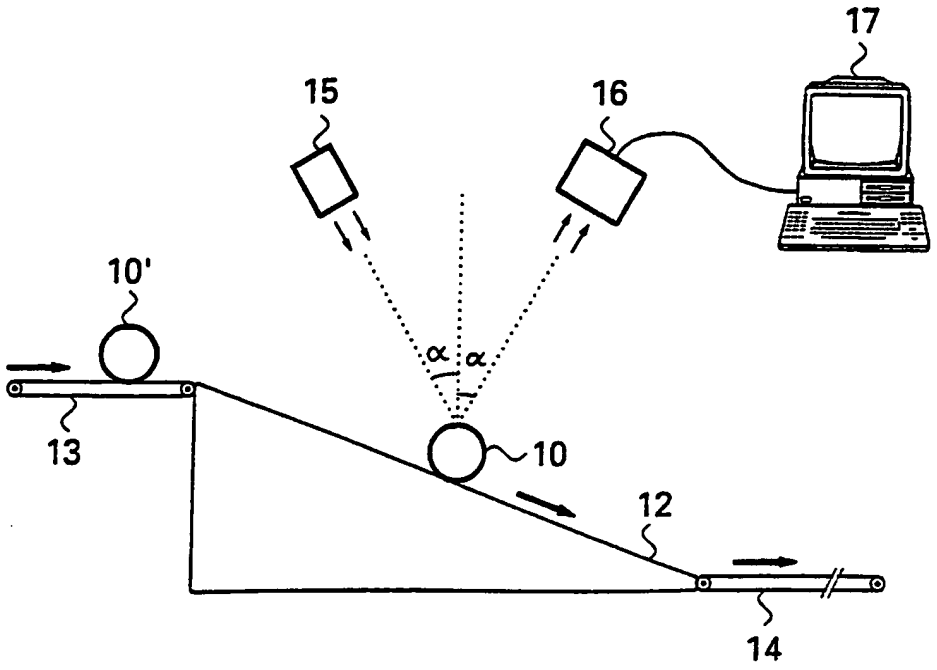

Fig. 3

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B07C5/344 G01R31/36 G01N27/00 B07C5/34 B07C5/342

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B07C G01R

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO,A,92 17791 (TITALYSE) 15 October 1992 cited in the application see the whole document	1-6,8, 10-12
A	GB,A,2 130 735 (THE ELECTRICITY COUNCIL) 6 June 1984 cited in the application see the whole document	1-3,5,6, 8,10,11
A	EP,A,0 611 106 (HEWLETT-PACKARD) 17 August 1994 see abstract see column 6, line 55 - column 8, line 22; figures 3,4	1-3,5,6, 10,11
A	EP,A,0 580 241 (PHILIPS) 26 January 1994	

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